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The COVID-19 induced joint replacement deficit in England, Wales and Northern Ireland

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**Summary 298**

*Background*

The COVID-19 pandemic has impacted health, economies and the functioning of societies globally. In addition to direct health effects, it has indirectly impacted population health by limiting access to non-COVID treatments, including joint replacements. The pandemic has necessitated re-organisation of healthcare with the private-sector providing support to public hospitals in some areas. The full impact is therefore difficult to ascertain from public data sources alone.

*Methods*

We used a mandatory prospective national register of private and publicly funded hip, knee, shoulder, elbow and ankle replacements in England, Wales and Northern Ireland. Descriptive analysis of the provision of joint replacement comparing data from 2019 to 2020 and predicted deficit recovery.

*Findings*

There was a substantial deficit in the provision of joint replacement in 2020 compared to 2019 with 106,922(48.8%) fewer procedures performed; resulting in 45,116 (44%) fewer hip replacements, 57,115(52%) fewer knee replacements, 3,878(50%) fewer shoulder replacements, 280 (33%) fewer elbow replacements and 533(53%) fewer ankle replacements performed. Wales and Northern Ireland were disproportionately affected with an overall reduction of 8,001(67%) and 2,833(64%) respectively compared to 96,088(47%) in England.

An immediate 5% expansion in provision from the 2019 baseline will eliminate the deficit over approximately 10 years (by 2031), whilst a 10% expansion will address the deficit by 2026.

*Interpretation*

This large national analysis of both private and publicly funded joint replacements illustrates a substantial accumulated deficit of surgery, equivalent to six-months of normal activity across England, Wales and Northern Ireland, due to the indirect effects of COVID-19. As the pandemic evolves, further waves of infection are likely to restrict surgery and see the deficit increase, therefore projections of time taken to address the deficit must thus be regarded as the best-case scenario. A significant expansion of joint replacement services compared 2019 is urgently required to address this deficit.

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## Introduction

Joint replacement is a common and important surgical procedure used to treat a variety of musculoskeletal problems including osteoarthritis and acute trauma. It is a highly successful procedure that reduces pain and disability enabling participation in and contribution to society. The Lancet described joint replacement as the operation of the 20th century.[1] Over 200,000 primary hip and knee replacements were performed in England, Wales and Northern Ireland in 2019 [2]. Joint replacements are long-lasting, with over half of hip and knee replacements lasting in excess of 25 years[3,4] and 90% of shoulder replacements lasting in excess of 10 years.[5] For very many people it is a curative procedure for the debilitating effects of end-stage arthritis.

The COVID-19 pandemic has had an unprecedented impact on populations around the world. The first patient with COVID-19 in the UK was identified on the 23rd January 2020[6] and the first UK national lockdown commenced on 23rd March 2020[7]. The pandemic has impacted our lives widely and has inevitably required in a massive and rapid re-organisation of healthcare provision in order to provide care for patients with severe acute respiratory distress due to SARS-Cov2 infection.

Less urgent medical procedures have been forgone or deferred due to competing pandemic demands. We have seen a re-organisation of services from public to the private sector and some hospitals have specialised in “COVID care”, whereas others have attempted to remain “COVID free” in an effort to provide more routine services. Early reports have suggested that mortality is persistently high (20.4%) following the acquisition of COVID-19 in the perioperative period after elective surgery.[8] Reports from around the world have suggested a wide variety of consequences of healthcare reorganisation including a reduction in the volume of joint replacement[9-13], an increased number of patients with symptoms “worse than death” whilst waiting for joint replacement[14], increased waiting lists[15] and economic hardship[16]. However, the majority of these reports have been based on single centres with small sample sizes. Assessing the impact of COVID-19 on the provision of joint replacement is difficult due to the shift in surgeries from the public to the private sector and the effective commandeering of private hospitals by NHS trusts. The analysis of single centres, public sector or private sector databases maybe misleading as they are unable to consider the totality of a healthcare system that has become increasingly integrated during this pandemic. A comprehensive analysis of both private and public sector provision is required to understand the impact of COVID-19 and plan the recovery of joint replacement capacity. Fortunately, England, Wales and Northern Ireland have an integrated mandatory register “The National Joint Registry” for all hip, knee, shoulder, elbow and ankle joint replacements.

We aim to describe the impact of the COVID-19 pandemic on joint replacement services in England, Wales and Northern Ireland and quantify the expansion of services required in order to address the accumulated deficit of joint replacement surgery and return joint replacement service provision back to pre-pandemic levels.

## Methods

*Data source*

In this prospective observational registry-based study we analysed data from the National Joint Registry (NJR)[2]. We collected data on hip, knee, shoulder, elbow and ankle primary joint replacement procedures entered into the registry from hospitals in England, Wales and Northern Ireland since its inception in April 2003 through to the end of December 2020. A data quality audit in 2017/18 showed over a 95% and 96% capture of all primary hip and knee data respectively (though this has subsequently been significantly improved by national audits)[2] .

The NJR data was prepared for this analysis in the same manner as described in the NJR 2020 17th Annual Report.[2] Data were cleaned by removing records with missing information, removing duplicate procedures, and removing records where we were unable to ascertain a logical sequence of revision procedures. The cleaning process resulted in 2,789,980 primary procedures for analysis (see supplementary figures 1 to 5).

*Statistical Analysis*

We used descriptive statistics to illustrate the impact of COVID-19 on the provision of joint replacement since the start of data collection for each type of joint replacement, dividing procedures into acute (those performed for trauma) and elective indications where possible.

We present weekly counts of procedures in 2019 compared to 2020 by each joint, dividing procedures into acute and elective indications where possible, and include a 21-day weekly rolling average.

The time-to-recovery and expansion in services required compared to 2019 was also calculated. We assume the years-to-recovery is estimated by deficit in procedures expressed as a percentage expansion of services compared to 2019 *i.e.* a 50,000 procedure deficit will take 5 years to recover assuming a baseline provision of 100,000 patients and a 10% expansion in surgical provision. We have simplistically assumed a static baseline (2019) though the secular patterns prior to this suggest

the need for increasing service provision (with the possible exception of knee replacement) so these estimates are likely to be conservative.

$$years\ to\ recovery = \frac{N_{2019} - N_{2020}}{\frac{N_{2019}}{100} \cdot \%expansion}$$

Time-to-recovery was calculated for England, Wales and Northern Ireland overall and for each nation separately.

*Sensitivity analyses*

Weekly frequencies were also calculated for all English sub-regions for all joints in 2020, dividing procedures into acute and elective indications where possible. Time-to-recovery was also calculated for all English sub-regions for all joints comparing provision to 2019. All analyses were conducted in Stata 15.1 StataCorp. College Station, TX.

*Role of the funding source*

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. AS, KD, EL had full access to all the data in the study and all authors had the final responsibility for the decision to submit for publication.

**Results**

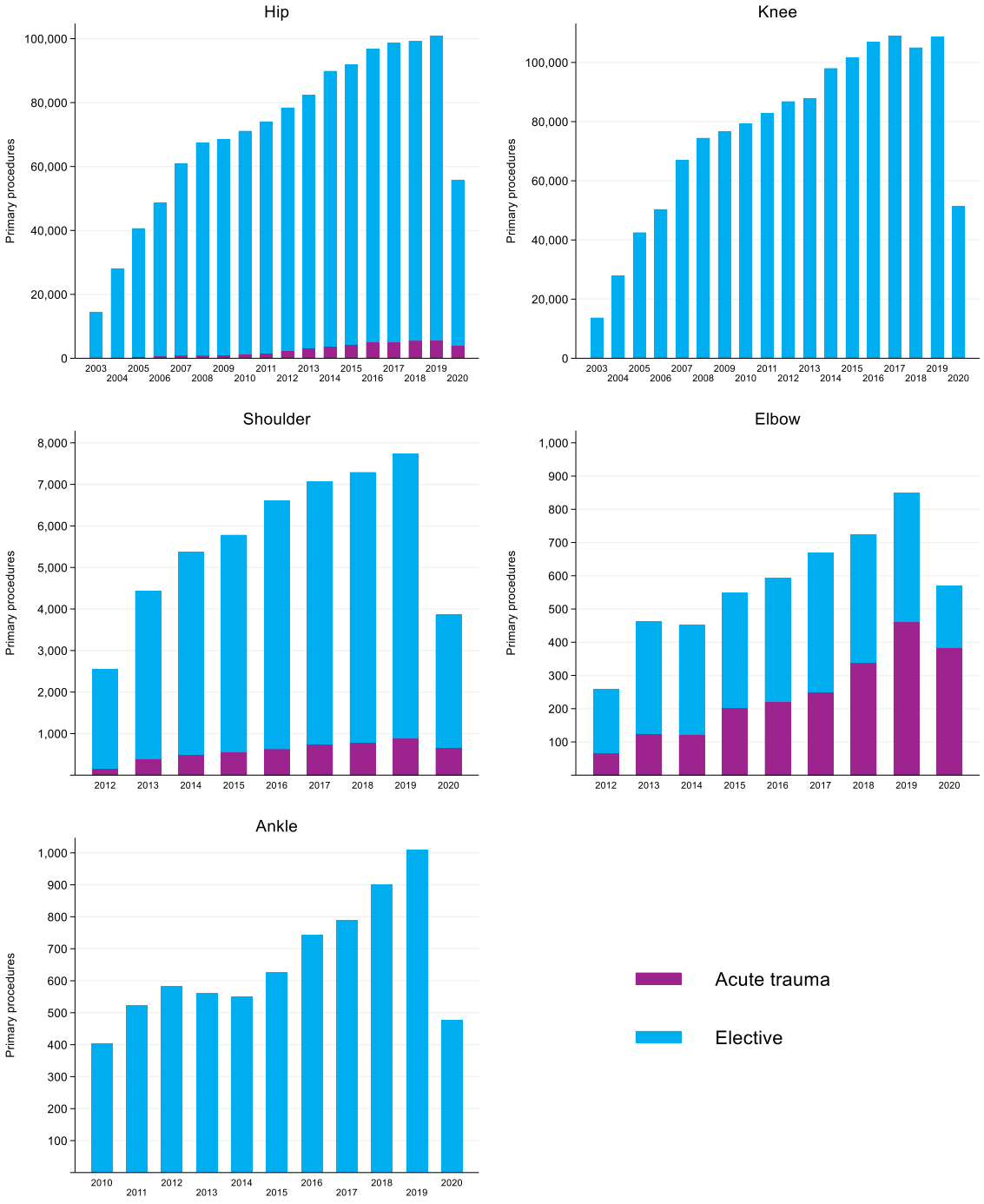
Overall, 106,922 (48.8%) fewer joint (hip, shoulder, elbow, ankle) replacements were performed in 2020 compared to 2019. Knee replacements showed the largest reduction in absolute numbers followed by hip replacements, see Table 1. Wales and Northern Ireland have recorded 67% and 64% fewer joint replacement procedures respectively compared to 2019, which is substantially greater than the deficit of 47% experienced by England.

Table 1: Descriptive statistics of provision and change of joint replacement by joint and nation.

| Joint | N(2019) | N(2020)= | N(Change) | %(Change) |
|---|---|---|---|---|
| **England, Wales and Northern Ireland** | | | | |
| Hip | 100,940 | 55,824 | -45,116 | -44.7 |
| Knee | 108,607 | 51,492 | -57,115 | -52.6 |
| Shoulder | 7,737 | 3,859 | -3,878 | -50.1 |
| Elbow | 850 | 570 | -280 | -32.9 |
| Ankle | 1,009 | 476 | -533 | -52.8 |
| **Total** | **219,143** | **112,221** | **-106,922** | **-48.8** |
| **England** | | | | |
| Hip | 93,148 | 52,818 | -40,330 | -43.3 |
| Knee | 100,547 | 49,169 | -51,378 | -51.1 |
| Shoulder | 7,373 | 3,736 | -3,637 | -49.3 |
| Elbow | 791 | 552 | -239 | -30.2 |
| Ankle | 961 | 457 | -504 | -52.4 |
| **Total** | **202,820** | **106,732** | **-96,088** | **-47.4** |
| **Wales** | | | | |
| Hip | 5,501 | 2,039 | -3,462 | -62.9 |
| Knee | 6,025 | 1,734 | -4,291 | -71.2 |
| Shoulder | 287 | 97 | -190 | -66.2 |
| Elbow | 43 | 9 | -34 | -79.1 |
| Ankle | 32 | 8 | -24 | -75.0 |
| **Total** | **11,888** | **3,887** | **-8,001** | **-67.3** |
| **Northern Ireland** | | | | |
| Hip | 2,291 | 967 | -1,324 | -57.8 |
| Knee | 2,035 | 589 | -1,446 | -71.1 |
| Shoulder | 77 | 26 | -51 | -66.2 |
| Elbow | 16 | 9 | -7 | -43.8 |
| Ankle | 16 | 11 | -5 | -31.3 |
| **Total** | **4,435** | **1,602** | **-2,833** | **-63.9** |

Figure 1 illustrates the difference in accrual of primary joint replacements since the start of data collection for each joint. Data have illustrated that provision of joint replacement has increased year on year since data collection started.

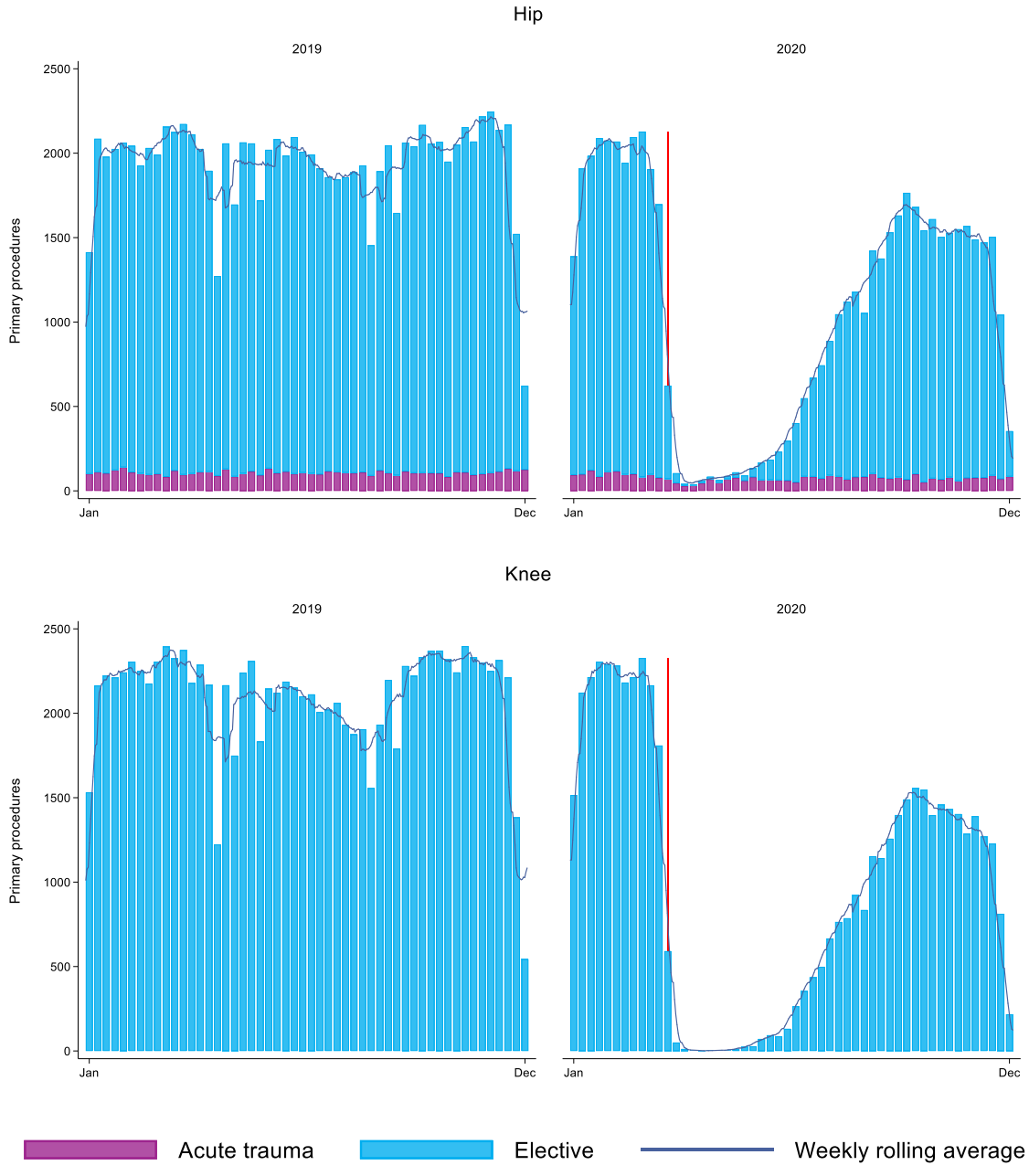
Figure 1: Annual number of primary hip, knee, shoulder, elbow and ankle replacements performed in England, Wales and Northern Ireland.




Figures 2 and 3 illustrate weekly counts of primary hip, knee, shoulder, elbow and ankle replacements in 2019 compared to 2020. These show a rapid decline in the number of procedures prior to the start of the first national lockdown. A very small number of elective joint replacements

were performed in the first 8 weeks following the first national lockdown. The volume of acute procedures (those performed for trauma) recorded in hip, shoulder and elbow replacements were also reduced in 2020 compared to 2019.

Figure 2: Weekly number of primary hip and knee replacements performed in England, Wales, and Northern Ireland in 2019 and 2020.




Graphs by year of primary operation
Red line indicates first national lockdown
Weekly (centred) rolling average based over 21 days

Figure 3: Weekly number of primary shoulder, elbow and ankle replacements performed in England, Wales, and Northern Ireland in 2019 and 2020.

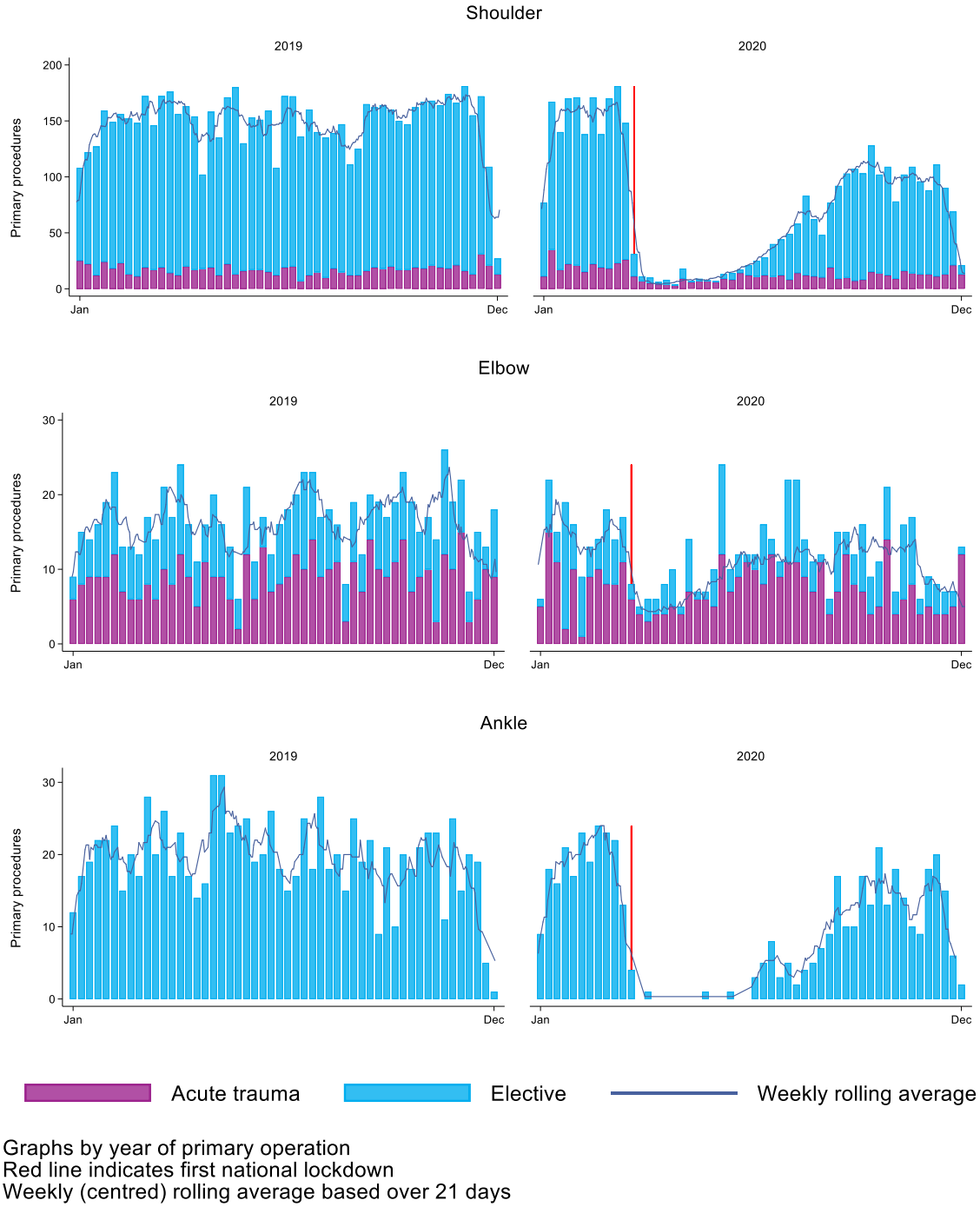
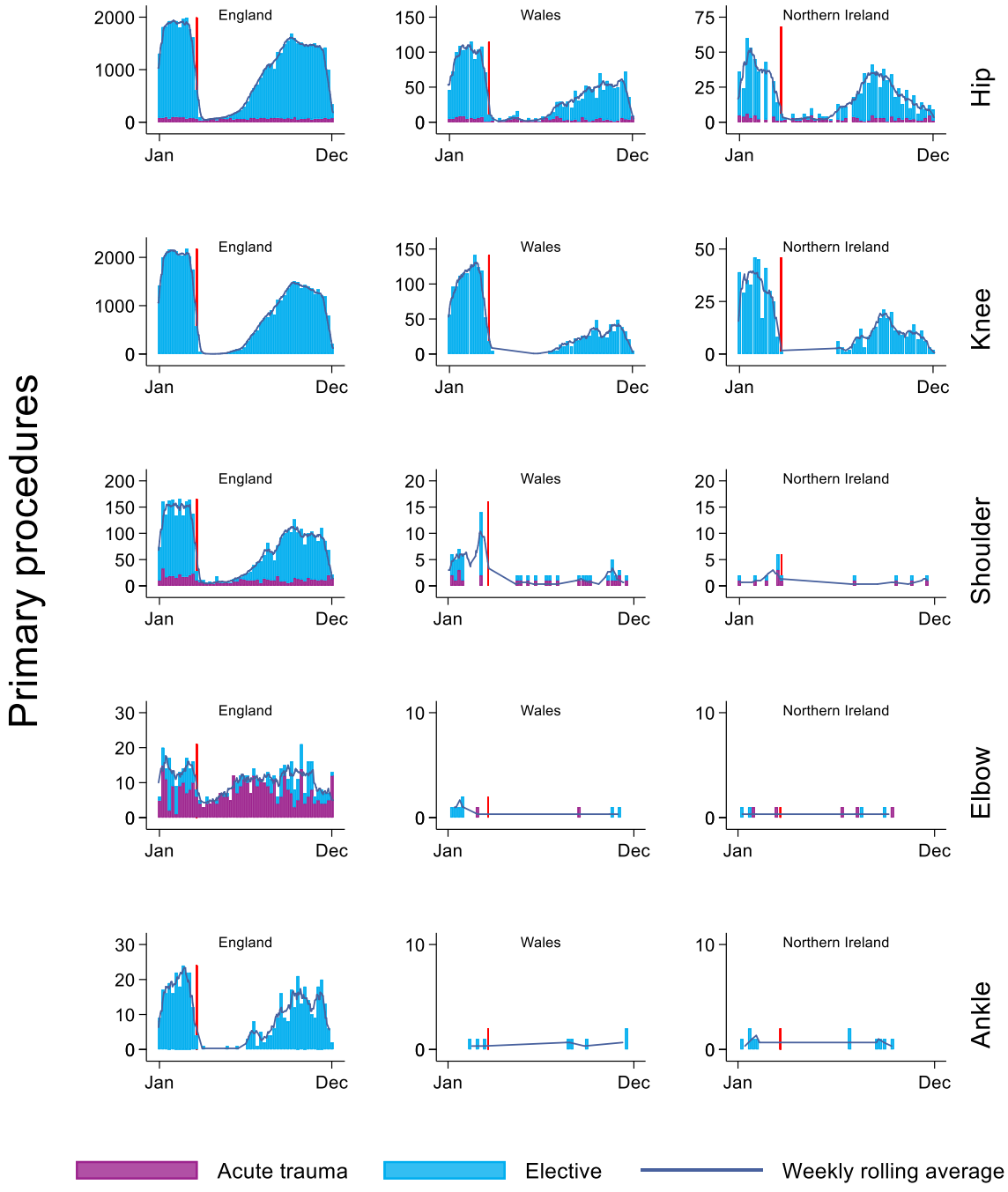



Figure 4 shows a breakdown of weekly counts of primary hip, knee, shoulder, elbow and ankle replacements in 2020 stratified by each nation. This shows that the reduced volume of joint replacements is not evenly distributed across England, Wales and Northern Ireland. The volume of procedures recorded in Wales and Northern Ireland in the second quarter of the year (2020) is

negligible compared to those recorded in England. This pattern is even more pronounced for shoulder, elbow and ankle procedures in the 2nd, 3rd and 4th quarters of 2020.

Figure 4: Weekly number of primary shoulder, elbow and ankle replacements performed in England, Wales, and Northern Ireland in 2020 by nation.




Supplementary figures 6 through to 10 and Supplementary Table 1 illustrate regional breakdown of weekly counts of primary hip, knee, shoulder, elbow and ankle replacements in 2020.

Supplementary figure 6 and 7 demonstrates heterogeneity in the recovery of hip and knee replacements from the first wave of COVID-19 infections, with some regions beginning restoring provision more rapidly, and to a greater extent, than others.

Figure 5 illustrates the years-to-recovery following expansion of provision compared to 2019 rates across England, Wales and Northern Ireland stratified by joint. This figure illustrates that an immediate 5% expansion in provision of hip, knee, shoulder, and ankle replacement compared to 2019 may address the deficit in procedures, within approximately 10 years. A 10% expansion in provision is projected to address the current deficit in approximately 5 years.

Figure 5: Predicted years-to-recovery of the 2020 deficit of joint replacement procedures following expansion of joint replacement provision compared to 2019 in England, Wales and Northern Ireland.

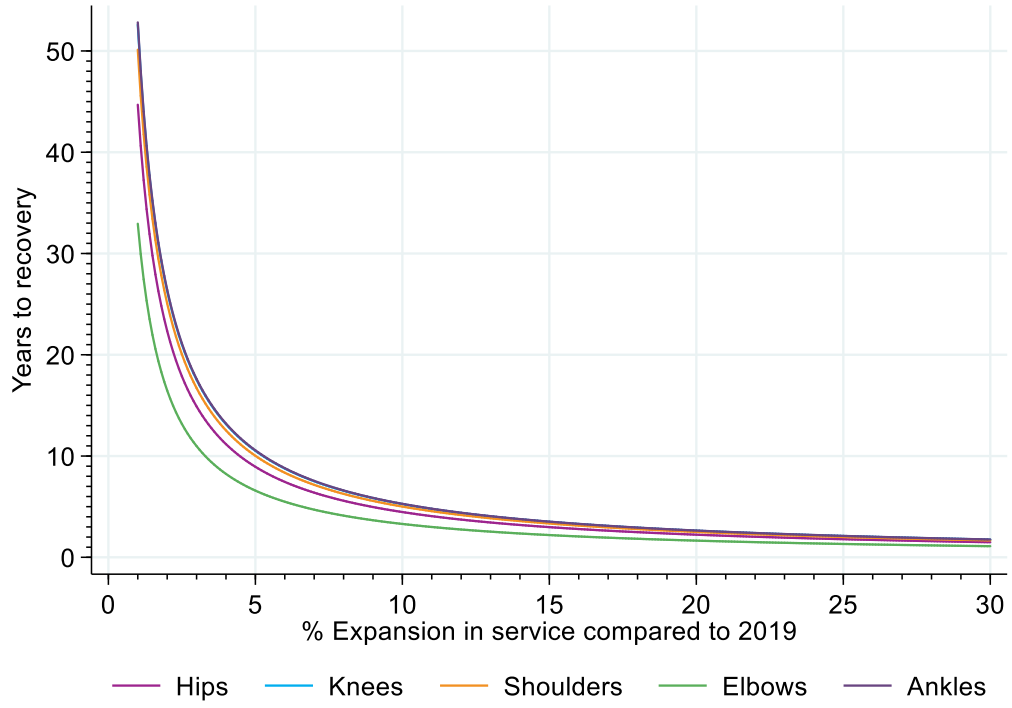
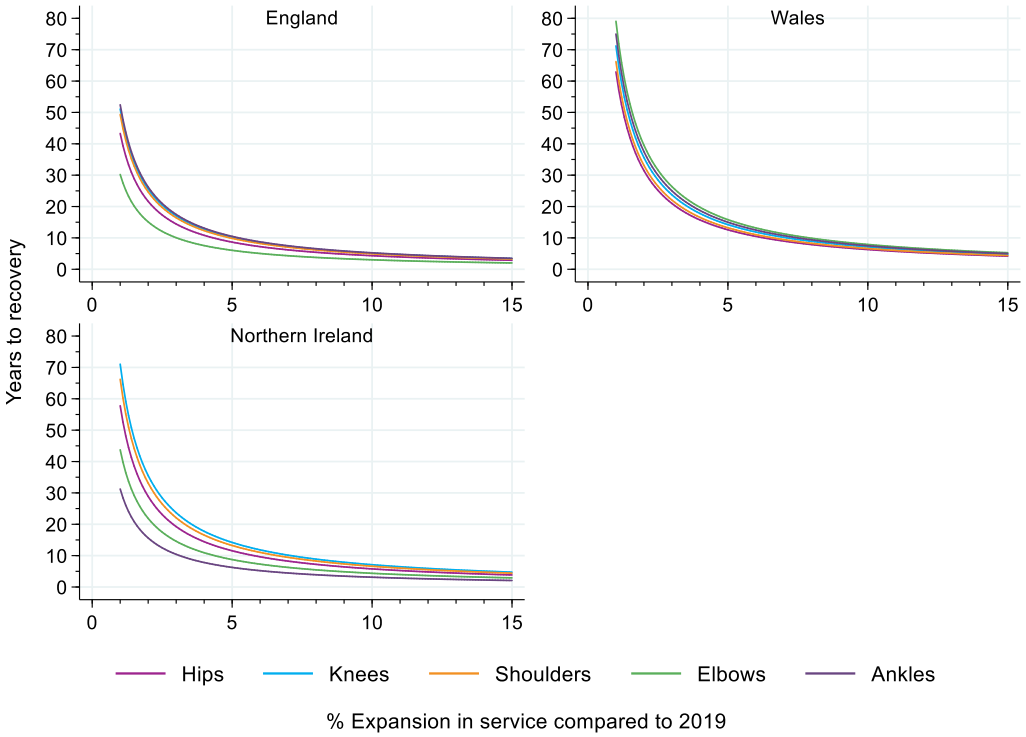



Figure 6 illustrates the years-to-recovery following expansion of provision compared to 2019 stratified by England, Wales and Northern Ireland and joint type. Figure 6 and data in Table 2 illustrate that the recovery in Wales and Northern Ireland will take longer for an equivalent expansion in services.

Figure 6: Predicted years-to-recovery of the 2020 deficit of joint replacement procedures following expansion of joint replacement provision compared to 2019 stratified by nation.




Supplementary figure 11 and supplementary Table 2 illustrates years-to-recovery following expansion of provision compared to 2019 stratified by region and joint type. These data illustrate heterogeneity in provision of joint replacement during 2020 and different recovery profiles in the 3rd and 4th quarters of 2020.

Table 2 predicted years-to-recovery of 2020 deficit following expansion of joint replacement provision compared to 2019 by joint type and nation.

| Expansion compared to 2019 (%) | Years to recovery | | | | |
|---|---|---|---|---|---|
| | Hip | Knee | Shoulder | Elbow | Ankle |
| **England, Wales and Northern Ireland** | | | | | |
| 5 | 8.9 | 10.5 | 10.0 | 6.6 | 10.6 |
| 10 | 4.5 | 5.3 | 5.0 | 3.3 | 5.3 |
| 15 | 3.0 | 3.5 | 3.3 | 2.2 | 3.5 |
| 20 | 2.2 | 2.6 | 2.5 | 1.6 | 2.6 |
| 25 | 1.8 | 2.1 | 2.0 | 1.3 | 2.1 |
| 30 | 1.5 | 1.8 | 1.7 | 1.1 | 1.8 |
| **England** | | | | | |
| 5 | 8.7 | 10.2 | 9.9 | 6.0 | 10.5 |
| 10 | 4.3 | 5.1 | 4.9 | 3.0 | 5.2 |
| 15 | 2.9 | 3.4 | 3.3 | 2.0 | 3.5 |
| 20 | 2.2 | 2.6 | 2.5 | 1.5 | 2.6 |
| 25 | 1.7 | 2.0 | 2.0 | 1.2 | 2.1 |
| 30 | 1.4 | 1.7 | 1.6 | 1.0 | 1.7 |
| **Wales** | | | | | |
| 5 | 12.6 | 14.2 | 13.2 | 15.8 | 15.0 |
| 10 | 6.3 | 7.1 | 6.6 | 7.9 | 7.5 |
| 15 | 4.2 | 4.7 | 4.4 | 5.3 | 5.0 |
| 20 | 3.1 | 3.6 | 3.3 | 4.0 | 3.8 |
| 25 | 2.5 | 2.8 | 2.6 | 3.2 | 3.0 |
| 30 | 2.1 | 2.4 | 2.2 | 2.6 | 2.5 |
| **Northern Ireland** | | | | | |
| 5 | 11.6 | 14.2 | 13.2 | 8.8 | 6.3 |
| 10 | 5.8 | 7.1 | 6.6 | 4.4 | 3.1 |
| 15 | 3.9 | 4.7 | 4.4 | 2.9 | 2.1 |
| 20 | 2.9 | 3.6 | 3.3 | 2.2 | 1.6 |
| 25 | 2.3 | 2.8 | 2.6 | 1.8 | 1.3 |
| 30 | 1.9 | 2.4 | 2.2 | 1.5 | 1.0 |

**Discussion**

We present the first comprehensive assessment of the provision of joint replacement across the entire health service (private and public) in England, Wales and Northern Ireland. The COVID-19 pandemic has had a profound impact on patients due to reduced service delivery of joint replacement surgery. Provision of joint replacement surgery in 2020 was reduced by approximately 50% compared to 2019. Patients requiring elective joint replacement have been impacted the most with acute trauma provision being largely preserved throughout 2020. The impact of COVID-19 has not been uniform across or within the nations covered by the NJR. Wales and Northern Ireland have seen the greatest reduction in capacity with surgery for patients requiring elective shoulder, elbow and ankle replacements effectively being halted.

We illustrate that to recover the accumulated deficit in joint replacement that has occurred in 2020 a significant expansion in pre-pandemic service provision is needed, even if it is assumed that demand remains static at 2019 levels, which is unlikely to be true given the year-on-year secular increase in the provision of most procedures except possibly knee replacement. The deficit in 2020 is equivalent to six-months of normal activity across England, Wales and Northern Ireland. Without expansion in provision, waiting lists for joint replacement will be, at a minimum six-months longer compared to pre-pandemic levels based on the assumption that services have been restored since January 2021. However, as provision had not recovered to pre-pandemic levels by the end of 2020, it is likely that the pandemic will continue to impact patients due to reduced provision of joint replacement services for at least the first half of 2021. Waiting lists will therefore continue to lengthen as the deficit increases.

Expanding provision in the post-pandemic NHS system will be challenging. Either greater productivity, equivalent to every hospital providing an additional 2.5 or 5 weeks of joint replacement provision per year, must be achieved which is unlikely to be feasible. An alternative strategy would be a 5% or 10% expansion in services crudely represents 10 or 20 new high volume treatment centres each providing 500 hip and 500 knee joint replacements per year. Staffing such facilities and providing all the ancillary care would also be extremely challenging. Any additional theatre capacity developed will require consultant orthopaedic surgeons, anaesthetic staff, theatre staff, nurses, physiotherapists and all the other ancillary services. Expanding staff capacity cannot take place overnight and presents the most serious challenge. Utilisation and efficiency solutions are likely to offer only a partial answer. Caution must also be exercised when attempting to expand capacity within existing staff, ensuring they are retained and supported in order that work-related “burn-out”

due to COVID-19 is not exacerbated. Similarly, the increased volume of post discharge care will have significant resource implications and impact on already stretched community-based services.

The removal of barriers to increasing capacity, such as annual[17] and lifetime pension allowances,[18] will be as important as incentivising 7-day a week operating, asking senior orthopaedic surgeons and anaesthetists to delay their retirement or asking recently retired surgeons and anaesthetists to return from retirement to assist in the provision of joint replacement are all strategies to be considered. Expanding bed capacity will be particularly difficult during winter months when, even prior to the pandemic, elective surgery is already routinely curtailed. Minimising seasonal variation in the volume of primary procedures performed will be essential in maximising service delivery; the role of private sector service provision is likely to be increasingly important in restoring provision of joint replacement.

The selection of evidence based joint replacement[19,20] and rehabilitation strategies which are cost-effective[21] and minimise the national healthcare and revision burden will be essential in maximising capacity of primary procedures, with NHS initiatives such as "Getting It Right First Time"[22] playing an important role. The rapid assessment of the clinical and cost-effectiveness of new treatment modalities, such as day case joint replacement,[23] and enhanced recovery programmes[24] are required if the capacity for primary joint replacement is to be maximised.

## Strengths and limitations

This analysis has a number of strengths. Importantly the data included in this analysis covers both private and publicly funded joint replacement procedures. Contribution to the registry is mandatory and primary case ascertainment is in excess of 95% for hip and knee replacements.[2]

We assume the latent demand for joint replacement will be the same as 2019, we have not accounted for the increased demand in joint replacement we have seen historically, which is approximately 5% per year.[2] We have not factored in the reduced demand for joint replacement due to the higher expected mortality in 2020, similarly we have also not accounted for the observed modest reduction in trauma related procedures in 2020, which we assume will have been treated using alternative strategies, *e.g*. hemiarthroplasty rather than total hip replacement as was recommended by NHS England in March 2020, in response to the demands of the pandemic[25], for patients with intracapsular hip fractures[26] or conservative management. We are under-estimating the impact on elective hip, shoulder and elbow joint replacement, as surgery for traumatic indications has been largely preserved throughout 2020. We also expect a modest lag in data entry,

which principally reduces volume estimates in the fourth quarter of 2020 (typically there is less than 5% late data entry beyond three months). There may also be a reduction in compliance in reporting procedures to the NJR because of indirect effects of the allocation of administrative staff during the COVID-19 pandemic response in individual hospitals. The model used to predict time-to-recovery is simplistic and has not accounted for demographic changes including an increasingly elderly population nor increasing life expectancy that we have historically observed. This analysis only considers the impact of the pandemic on activity in 2020, the pandemic principally impacted provision in the last three quarters of 2020 and has continued to effect provision in 2021 and are likely to make predictions very conservative.

**Conclusion**

We have been able to reliably assess the impact on patients waiting for joint replacement, created by the effects of COVID-19 in 2020, using a nationally representative data source. The provision of primary joint replacement declined by approximately 106,000 cases (50%) in 2020 in England, Wales and Northern Ireland. This will inevitably lead to a large number of patients enduring unnecessary pain, disability and secondary decline in mental and overall physical well-being. The impact on waiting times, in an already overstretched healthcare system, is extremely concerning and likely to deteriorate further in 2021 at least. Returning to pre-pandemic provision is not sufficient, as this will not address the deficit in joint replacement and even with a rapid expansion in service provision to address this deficit in provision, our study indicates it will take many years to resolve this joint replacement crisis.

**Table List**

Table 1: Descriptive statistics of provision and change of joint replacement by joint and nation.

Table 2 predicted years-to-recovery of 2020 deficit following expansion of joint replacement provision compared to 2019 by joint type and nation.

**Declaration of interests**

AS, KD, EL, AJ CLG, EMC, JLR, AJP, YBS, MRW, AWB are members of The National Joint Registry analysis team and contracted to conduct routine data analysis for the National Joint Registry for quality assurance purposes and routine report generation.

AS reports funding from the MRC to his institution unrelated to this work.

EL reports funding from CeramTec to his institution unrelated to this work.

JLR reports funding from The National Joint Registry unrelated to this work.

AJ reports personal fees from Freshfields, Bruckhaus, Derringer and Anthera Pharmaceuticals Ltd unrelated to this work.

CLG reports grants from GCRF, ORUK, EBI, Wellcome, EDTCP, Versus Arthritis, Chartered Society of Physiotherapists unrelated to this work.

EMC reports grants from Versus Arthritis and NIHR unrelated to this work.

MR reports grants from Zimmer, The Health Foundation, Heraeus, 3m Healthcare, Sheulke, Aquilant, Biocomposites, Stryker, Depuy, Smith and Nephew, Bone Support, NIHR, Ethicon, Convatec unrelated to this work.

DP reports no conflict of interests

JMW reports reimbursement for role as chair of the NJR Research Committee and Executive Committee and grant income from Helmholtz Institute, Munich, Germany; Amgen, Inc; Versus Arthritis; Wellcome Sanger Institute; Medical Research Council; Health Quality Improvement Partnership; NIHR Academic Clinical Fellowship Programme; NIHR Health Technology Assessment Programme; NIHR Research Policy Programme unrelated to this work

AP reports grant funding from NIHR unrelated to this work and teaching fees from Zimmer Biomet unrelated to this work.

TW reports reimbursement from the The National Joint Registry and honoraria from Smith and Nephew, Pfizer unrelated to this work.

MRW reports institutional funding from NIHR, Stryker, Ceramtec, Depuy, Heraeus unrelated to this work and royalties from Taylor Francis in relation to a textbook “Apley & Solomon's System of Orthopaedics and Trauma 10th Edition”

AWB reports institutional funding from NIHR, Stryker and Ceramtec unrelated to this work and royalties from Taylor Francis in relation to a textbook “Apley & Solomon's System of Orthopaedics and Trauma 10th Edition”

**Contributors**

AS was responsible for study concept, data analysis, and writing – original draft of the article, and writing – review & editing.

KD and EL were responsible for data analysis, writing – review & editing.

SKK was responsible for searching literature, writing – review & editing.

AWB, MRW, AJ, YBS, CLG, EMC, JR, AP, were responsible for study concept, funding acquisition, and writing – review & editing.

MR, TW, RMW, DP were responsible for study concept, project administration, and writing – review & editing.

AS, KD, EL have accessed and verified the underlying data.

**References**


1. Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. *Lancet* 2007; **370**(9597): 1508-19.
2. Ben-Shlomo Y, Blom A, Boulton C, et al. The National Joint Registry 17th Annual Report 2020. London; 2020.
3. Evans JT, Evans JP, Walker RW, Blom AW, Whitehouse MR, Sayers A. How long does a hip replacement last? A systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow-up. *Lancet* 2019; **393**(10172): 647-54.
4. Evans JT, Walker RW, Evans JP, Blom AW, Sayers A, Whitehouse MR. How long does a knee replacement last? A systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow-up. *Lancet* 2019; **393**(10172): 655-63.
5. Evans JP, Evans JT, Craig RS, et al. How long does a shoulder replacement last? A systematic review and meta-analysis of case series and national registry reports with more than 10 years of follow-up. *Lancet Rheumatol* 2020; **2**(9): E539-E48.
6. Lillie PJ, Samson A, Li A, et al. Novel coronavirus disease (Covid-19): The first two patients in the UK with person to person transmission. *J Infect* 2020; **80**(5): 578-606.
7. Johnson B. Prime Minister's statement on coronavirus (COVID-19): 23 March 2020 2020. https://www.gov.uk/government/speeches/pm-address-to-the-nation-on-coronavirus-23-march-2020.
8. Collaborative CO. Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. *Lancet* 2020; **396**(10243): 27-38.
9. Dillon MT, Chan PH, Prentice HA, et al. The effect of a statewide COVID-19 shelter-in-place order on shoulder arthroplasty for proximal humerus fracture volume and length of stay. *Semin Arthroplasty* 2021.
10. Simon S, Frank BJH, Aichmair A, et al. Impact of the 1st and 2nd Wave of the COVID-19 Pandemic on Primary or Revision Total Hip and Knee Arthroplasty-A Cross-Sectional Single Center Study. *J Clin Med* 2021; **10**(6).
11. D'Apolito R, Faraldi M, Ottaiano I, Zagra L. Disruption of Arthroplasty Practice in an Orthopedic Center in Northern Italy During the Coronavirus Disease 2019 Pandemic. *J Arthroplasty* 2020; **35**(7S): S6-S9.
12. Decruz J, Prabhakar S, Ding BTK, Kunnasegaran R. The COVID-19 pandemic in Singapore: what does it mean for arthroplasty? *Acta Orthop* 2020; **91**(5): 551-5.
13. Shih CL, Huang PJ, Huang HT, Chen CH, Lee TC, Hsu CH. Impact of the COVID-19 pandemic and its related psychological effect on orthopedic surgeries conducted in different types of hospitals in Taiwan. *J Orthop Surg (Hong Kong)* 2021; **29**(1): 2309499021996072.
14. Clement ND, Scott CEH, Murray JRD, Howie CR, Deehan DJ, Collaboration IM-R. The number of patients "worse than death" while waiting for a hip or knee arthroplasty has nearly doubled during the COVID-19 pandemic. *Bone Joint J* 2021; **103-B**(4): 672-80.
15. Jain A, Jain P, Aggarwal S. SARS-CoV-2 Impact on Elective Orthopaedic Surgery: Implications for Post-Pandemic Recovery. *J Bone Joint Surg Am* 2020; **102**(13): e68.
16. Brown TS, Bedard NA, Rojas EO, et al. The Effect of the COVID-19 Pandemic on Electively Scheduled Hip and Knee Arthroplasty Patients in the United States. *J Arthroplasty* 2020; **35**(7S): S49-S55.
17. Pandit JJ. Pensions, tax and the anaesthetist: significant implications for workforce planning. *Anaesthesia* 2016; **71**(8): 883-91.
18. Rimmer A. NHS pensions: what do changes to the lifetime allowance mean? *BMJ* 2021; **372**: n660.

19. Evans JT, Blom AW, Timperley AJ, et al. Factors associated with implant survival following total hip replacement surgery: A registry study of data from the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man. *PLoS Med* 2020; **17**(8): e1003291.
20. Beard DJ, Davies LJ, Cook JA, et al. The clinical and cost-effectiveness of total versus partial knee replacement in patients with medial compartment osteoarthritis (TOPKAT): 5-year outcomes of a randomised controlled trial. *Lancet* 2019; **394**(10200): 746-56.
21. Wylde V, Artz N, Marques E, et al. Effectiveness and cost-effectiveness of outpatient physiotherapy after knee replacement for osteoarthritis: study protocol for a randomised controlled trial. *Trials* 2016; **17**(1): 289.
22. Briggs T. Getting It Right First Time - Orthopaedic Surgery. 2020. https://www.gettingitrightfirsttime.co.uk/surgical-specialty/orthopaedic-surgery/.
23. Lazic S, Boughton O, Kellett CF, Kader DF, Villet L, Riviere C. Day-case surgery for total hip and knee replacement: How safe and effective is it? *EFORT Open Rev* 2018; **3**(4): 130-5.
24. Judge A, Carr A, Price A, et al. The impact of the enhanced recovery pathway and other factors on outcomes and costs following hip and knee replacement: routine data study. Southampton (UK); 2020.
25. England N. Clinical guide for the perioperative care of people with fragility fractures during the Coronavirus pandemic. 2020. https://www.boa.ac.uk/uploads/assets/3e2ef4d7-6788-4fcd-8a17196fca00f63e/NHSE-Fragility-Fractures-and-Coronavirus-VBOA10-24032020docx.pdf.
26. National Institute for Health and Care Excellence. Hip fracture: management. 2017. www.nice.org.uk/guidance/cg124.